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(57) Abstract

The present invention relates to a range determination apparatus, in particular to a laser range finding apparatus. Presently available range finders usually provide a read out of the range to a single target and are unable to distinguish between multiple targets. Either the largest signal or the signal of the target closest to the range finder will generally be the one displayed. The present invention provides a display of range to multiple targets and also a display of the relative strength of each of the multiple target signal returns. This enables an operator to distinguish between targets in his field of view and locate the desired target and the range thereto. The display is preferably histogrammatic.

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RANGE DETERMINATION APPARATUS

The present invention relates to a range determination apparatus and, more particularly, but not exclusively, to a laser rangefinding apparatus and, even more particularly, to the processing of the return signals in a laser rangefinding apparatus.

A rangefinder is an electro-optic device used to obtain the distance to a selected target e.g., military target. The target is viewed and selected through a viewing device similar to a telescope, a laser is "fired" and a single invisible infrared laser pulse is emitted towards the target(s). The pulse is reflected by the target back to the rangefinder and detected by optics and electronics in the rangefinder.

In rangefinders currently in military service, a simple threshold detector is used to terminate a clock count when it is detected that the signal return rises above a predetermined threshold, so indicating the presence of a reflection from a target. The clock is initiated on firing of the laser pulse, so that elapsed time between clock initiation and termination can be used to calculate the range to the target. Conventional analogue rangefinders are subject to a number of problems.

The shape of the signal return pulse from the target (target signal return) can be strongly influenced by obstacles between the rangefinder and the target, e.g., aerosols in the atmosphere (dust, smoke, moisture). Because a simple threshold detector is used to terminate a clock count, corruption of the shape of the signal return pulse can give rise to significant range errors.

Further, in most practical applications, it is inevitable that the laser pulse will be reflected from sources other than the desired target, e.g., trees, foot soldiers, background topography, which also lie in the path of the laser beam. The analogue return signal is therefore likely to include reflection information on multiple targets, not just the desired target. A simple

threshold detector is unable to distinguish between multiple targets which exceed the threshold. The signal from the target closest to the detector will generally be the only one recorded. To have any confidence in the range results, therefore, the operator may have to re-fire the rangefinding apparatus a number of times until the correct target is identified. It may also be necessary for him to move the apparatus one or more times in order to obtain confidence in his results. As well as reducing battery life of the rangefinding device, because of the necessity to re-fire the laser a number of times, the operator may be exposed to the enemy for a relatively long period of time.

Some prior art rangefinders provide a fixed "gating" facility. This enables the rangefinder to ignore signal returns within a predetermined distance of the rangefinder, e.g., within the first two kilometres. This may enable the operator to ignore obstacles within two kilometres of where he is standing, for example. It still does not, however, provide him with confidence in any target signal returns received outside the gated distance, which may still include multiple targets.

Some prior art rangefinders also offer a first/last target facility, which enables the operator to select the first or the last target signal return for ranging. Again, however, any other signal returns are not taken into account so that the operator still cannot be confident that the ranging results relate to his desired target.

Prior art systems are also available which have an adjustable gating range. To set the correct gating, however, requires a great deal of operator experience and estimation of distance by the eye. Again, the operator cannot be fully confident of his results.

Systems are available which apply digital processing to the analogue laser return signal in order to obtain more accurate distance information on target signal returns. These systems do not, however, offer any

more in the way of analysing multiple signal returns, although some do include gating and first/last facilities. As far as the applicants are aware, there is no laser rangefinder which processes the return signal to obtain information on all target signal returns received from multiple targets, to assist the operator in determining which of the multiple target signal returns relates to his desired target.

From a first, general aspect, the present invention provides, in a laser rangefinder, an apparatus for processing an analogue return signal for providing information on multiple target signals within a laser return signal to assist an operator to select and obtain the range to a desired target among multiple targets.

From a further, more specific aspect, the present invention provides in a rangefinding device, apparatus for processing an analogue return signal to recover range information on multiple targets, comprising digital analysis means arranged to digitally analyse the return signal to identify target signals, being signal returns which satisfy predetermined criteria, range determination means arranged to make a determination of the range of each target identified, and a display controller arranged to control a display to simultaneously display information on at least a plurality of the identified target signals to give an indication of the relative positions of the plurality of targets corresponding to the plurality of target signals.

The analogue return signal received by the rangefinding device after a laser pulse has been fired towards the desired target will generally include, as well as reflected signals from the desired target and any other targets within the laser path, noise generated internally within the receiving circuitry, noise generated by aerosols (e.g., dust, smoke, moisture) and signals from reflection from the background topography.

In a preferred embodiment, the present invention provides for the entire received signal to be first

sampled at a sampling frequency of 40 MHz. Thus the time between samples represents 7.5 metres of round trip travel (3.75 metres of range) for the laser pulse at the velocity of light. All samples are stored for digital signal processing.

Signal processing algorithms first perform a statistical analysis of the noise on the stored signals. The algorithms then analyse the stored signal, searching for signals which statistically differ from the noise on the relevant section of the record. The algorithms then search for "abnormal" pulses which may indicate that abnormal aerosol conditions e.g., smoke or dust at close range, would indicate that it may be preferable to use "de-cluttering" techniques (see later). The algorithms then analyse all signals which statistically differ from noise, determine the slope of signals and interpolate a line of best fit back to determine a first instant at which the signal began to appear (even though the signal will at that time be below the noise level). This then provides an accurate estimate of the range. The processing algorithms then analyse the detected signals, classify them according to relative amplitude and, in the preferred embodiment, display the five largest return signals (greatest amplitude). In the preferred device, the number of signals displayed can be changed to be a smaller or larger number of displayed signals.

In a preferred embodiment, multiple signal returns within a "cluster" of targets can be identified as separate targets provided they are displaced in range by more than thirty metres. If the individual targets in a "cluster" are displaced in range by less than thirty metres then the range is indicated to the closest target reflection and the "cluster" is identified as a single target.

Information on a plurality of the target signals whose range/relative range has been determined is displayed for view by the operator. In a preferred embodiment (as discussed above), information on five

targets is displayed in order to prevent crowding of the display. A larger or smaller number of targets may be displayed by re-configuration of software.

The display is preferably a graphical display, which shows a representation of each target separated from representations of the other targets by distances in the graphical display which indicate relatively the distances by which the actual targets are separated. The display is preferably a histogrammatic display, each target being represented by a histogram bar placed on a base line, the separation distance of adjacent histogram bars on the base line being indicative of the relative separation of the actual targets.

By reference to the display of relative range information and information in his visible line of sight, the operator can preferably make a more accurate judgement as to which of the targets is his desired target. He can then obtain a read out of the actual range to his desired target, or to any one of the displayed targets.

Preferably, control means are provided to enable the operator to select any of the displayed targets to obtain a display read out of the actual range to the selected target. The preferred embodiment of the present invention is not, therefore, limited to calculation and display of the range of only a limited number of targets, e.g., first/last target, as in the prior art. The operator can obtain a read out of the range of all displayed targets. In alternative embodiments, information on all targets from which a target signal return is received may be displayed and the operator may obtain information on all targets.

Preferably, the display controller is arranged to control the display to display information indicating the relative strength of at least the plurality of target signals. In a preferred embodiment, the relative strength is indicated by the height of the histogram bar representing the target on the display. The indication

of relative strength of return signals gives the operator more information from which to identify the desired target. In most cases, the desired target provides the largest return signal. In cases where it does not provide the largest return signal, this should be clear to the operator from his line of sight view, i.e., a hill behind the desired target may, in some case, provide the largest signal, in which case the largest signal would be discounted by the operator, and the range to other targets would be determined by the operator.

Preferably, the range determination means is arranged to determine whether a plurality of targets are within a predetermined range of each other and, if so, to determine that the plurality of targets are "clustered". The display controller is responsive to such a determination to cause the display to indicate that the plurality of targets are clustered. In a preferred embodiment, this indication is made by increasing the width of a histogram bar on the display. The wider histogram bar indicates it represents a plurality of target signals from targets which are within a predetermined distance of each other. This further information assists in identifying the desired target. Where a number of clustered targets appear in the laser path, e.g., multiple vehicles in a group, processing and determining range to the individual targets provides the means of precise target selection. Where there are number of targets detected which fall within a range span, in the preferred embodiment, of 1000 metres, they are displayed as a "clustered target" by means of a wide bar on the histogram and the operator may, by using control buttons, measure and display range to each and every one of the multiple targets within the cluster in turn.

From a further aspect, the present invention provides, in a rangefinding device, apparatus for processing an analogue return signal to recover information on multiple targets, comprising digital

analysis means arranged to digitally analyse the return signal to identify target signals, being signal returns which satisfy predetermined criteria, and arranged to make a determination of the strength of a plurality of target signals, and a display controller arranged to control a display to display information on the relative strength of the plurality of target signals.

Information on the relative strength of return signals preferably assists the operator in identifying which of the return signals relates to his target. Preferably, the apparatus of this aspect of the invention may include any or all of the features discussed in relation to the previous aspect of the present invention, including determination and display of relative ranges, indication that targets are "clustered", etc.

The present invention yet further provides, in a rangefinding device, an apparatus for processing an analogue return signal to recover range information on multiple targets, comprising digital analysis means arranged to digitally analyse the return signal to identify all targets from which a reflection has been received and are included in the return signal, being signal returns which satisfy predetermined criteria.

This aspect of the invention may include any or all of the features of the aspects discussed above.

The provision of information on all target signals received by the laser rangefinding device assists greatly in enabling the operator to identify the desired target.

From another aspect, the present invention yet further provides, in a rangefinding device, a method of processing an analogue return signal to recover range information on multiple targets, comprising the steps of digitally analysing the analogue return signal to identify target signals, being signal returns which satisfy predetermined criteria, determining the range of each target identified, and controlling a display to simultaneously display information on at least a

plurality of the identified target signals to give an indication of the relative positions of the plurality of targets corresponding to the plurality of target signals.

The present invention yet further provides in a rangefinding device, a method of processing an analogue return signal to recover information on multiple targets, comprising the steps of digitally analysing the analogue return signal to identify target signals, being signal returns which satisfy predetermined criteria, determining the strength of each of a plurality of the target signals and controlling a display to display information indicating the relative strength of at least the plurality of target signals.

The present invention yet further provides in a rangefinding device, a method of processing an analogue return signal to recover information on multiple targets, comprising the steps of digitally analysing the analogue return signal to identify all target signals included in the return signal, being signal returns which satisfy predetermined criteria, predetermined criteria including the strength of the signal return, a signal return being identified as a target signal if it is over a predetermined strength value.

Features and advantages of the present invention will become apparent from the following description of an embodiment thereof, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a top, partially-sectioned view of a rangefinding device incorporating apparatus in accordance with an embodiment of the present invention;

Figure 2 is an end view from one end of the device of figure 1;

Figure 3 is a schematic block diagram showing optics and electronic circuitry for operation of the device of figure 1;

Figures 4a to c show an example of a multiple target situation, an example of the analogue return signal from the multiple target situation and an example

of the signal display in accordance with an embodiment of the present invention, following the processing of the analogue return signal; and

Figure 5a to d are drawings showing example displays in accordance with the embodiment of the present invention;

Referring to figures 1 and 2, a rangefinder device, generally designated by reference numeral 1, comprising a housing 2 mounting electronic circuitry, a laser source, optics and display for firing a laser pulse, detecting reflections of the pulse from multiple targets, and providing a read out of target range. The device has military and commercial application. It may be used on the battlefield to establish the range of a desired target for weapon aiming and firing. It can also be used in commercial applications, such as recreational boating, police (Marksman), SES (Search and Rescue), coast watch (location and mapping of contacts), airports (windshear detection and cloud height).

The rangefinder 1 mounts within the housing 2 an Erbium glass laser for providing Infrared Radiation at the eye safe wavelength of 1540nm. Appropriate optics (not shown in figures 1 or 2, although mounted generally in the area indicated by reference numeral 3) shape the laser beam. The viewer optics (again not shown) provide a line of sight image for the operator and contain cross hairs. The operator is able to focus on the desired target through the viewer optics. The operator views the target through adjustable eyepiece 4. Further optics (again not shown) are provided to detect a laser signal return reflected from targets, and a detector (not shown) is arranged to detect the return signal. An apparatus in accordance with an embodiment of the present invention digitally processes and analyses a signal to provide a display able to simultaneously display information on multiple targets, including information on their relative range, and relative amplitude of the target return signal associated with each target. The operator is able to

view the display through the viewer eyepiece 4.

The entire device is sheathed in rubber armour 5 for protection from damage. A high impact nylon case with EMI/EMC shielding 6 underlies the rubber armour 5. Operator controls include a charge button 7, for causing the Erbium glass laser to charge, a menu button 8 for choosing options, selection buttons 9 for selecting a target signal from the display, to obtain a read out of range to the selected target, a fire button 10 for causing the laser to be fired after it has been charged and an on/off switch 11.

Referring to figure 1, the position of some internal components of the device is designated schematically. A battery compartment 12 mounts batteries to power the device. A battery cap 13 is provided at one end of the device 1, for access to the battery compartment 12. The optical components for the line of sight display are housed generally in the area designated by reference numeral 14. In accordance with the present invention, components of an electronic cathode ray tube display are housed generally in the area designated by reference numeral 15 and are operated to provide a display representative of multiple target returns, indicating their relative positions and relative strength (see later).

Referring to figure 2, the device is provided with an options interface RS232 port 16 for interfacing with options such as global positioning systems. It is also provided for an RS232 communication port for interfacing with an external computer 4, for example, for automatically providing range information to weapons.

Referring again to figure 1, a slip resistance finger grip 18 is provided on the housing.

The major components of the laser rangefinding device will now be described in more detail with reference to the schematic block diagram of the components shown in figure 3.

For convenience, the components of the device

have been divided into functional blocks. A control block 20 includes a 68HC11 microprocessor 21 arranged to control all operational aspects of the rangefinding device. It incorporates an internal 2 kilobyte EEPROM memory and it is connected to a 128 Kbyte FLASH memory (not shown) containing control and analysis software, for enabling control of the device and digital analysis of the return signal.

Control block 20 further comprises interface circuitry 22 connected to the microprocessor 21 enabling interfacing with operator controls (e.g., laser "fire" button, display range selection buttons, etc) and enabling interfacing with externally mounted options such as global positioning satellite interface, inclinometer and compass. Operator controls are designated in the block 20 by reference numeral 23 and externally mounted options are designated by reference numeral 24.

Control block 20 also comprises a further microprocessor, being a TMS 320C 25 microprocessor 25. This microprocessor 25 is responsible for the digital signal processing and analysis of the return signal. Analysis software for the microprocessor 25 is stored in the 128 Kbyte FLASH memory (see above).

The device further comprises a power source block 26, including batteries 27 and battery management circuitry 28. The microprocessor 21 and battery management circuitry 28 are responsible for monitoring battery voltage and power supply to all critical areas. If no operator control 23 is actuated within a predetermined time (20 seconds) the microprocessor 21 is arranged to turn the device off, to save power supply. The microprocessor 21 also controls the display (see later) to indicate when the battery 26 voltage is low.

The power source block 26 also incorporates a low voltage power supply 29 which is responsible for powering the microprocessor 21 and other low voltage circuitry in the device. Note that the microprocessor 21 includes an internal battery backed static RAM (SRAM).

Electro-optic components for providing the laser pulse basically comprise three blocks. Laser power supply block 30 comprises a high voltage power supply 33 (the power source being provided by battery management circuit 28 and battery 27) and discharge circuit 34 for providing a discharge to power the laser. Block 31 comprises a laser module block 35 which incorporates an Erbium glass laser and Q-switch. An Idium Gallium Arsenide PIN diode 36, or alternatively an Avalanche Photo Diode (APD) is provided to detect reception of a laser pulse and initiate a counter (see later). Block 32 consists of transmitter optics for transmitting the laser pulse from the laser module 35. It consists of a Galilean telescope arrangement 37, 38 for collimating the laser beam.

Block 39 designates the receiver optics for receiving the laser return signal and visible radiation for provision of a line of sight view for the operator. The collection system has a clear aperture of 50mm and consists of an optimised doublet and an aplanatic meniscus lens 40. With this arrangement, spherical aberration is insignificant and coma is negligible. The meniscus lens is used to reduce the f-number of the system. The laser reflection signal (return signal), at 1540nm is passed through a small 45° wavelength filter 41 to a receiver. Visible radiation is reflected from filter 41 to block 42, to provide the operator line of sight view.

Block 42 designates operator viewing optics, including a 45° mirror 43 for directing visible radiation through a lens system 44, including eyepiece 4 which constitutes a standard type terrestrial telescope giving a 7° field of view and times 7 magnification. Block 42 also includes a monochromatic cathode ray tube (CRT) 45 and beam splitter 46 for providing a line of sight display to the eyepiece 4, the line of sight display providing information on multiple target signal returns. The microprocessor 21 acts as display controller for the

CRT display 45.

Block 47 includes componentry for detecting, amplifying and bandwidth limiting the analogue return signal, which includes target signal returns on any targets in the path of the laser beam. An Indium Gallium Arsenide PIN diode 48 is used to detect the return signal. Alternatively, the PIN diode may be replaced by an Indium Gallium Arsenide avalanche photodiode to increase sensitivity. If an avalanche photodiode is used as the detector, an HV biased supply 49 is required. A hybrid video amplifier 50 and variable gain amplifier 51 are provided to amplify the return signal. Note that the hybrid video amplifier may be integral with the detector 48. Both amplifiers 50 and 51 have variable gains which are controlled by a gain control (see later). A bandwidth limiter 52 is provided to limit the band width of the return signal and a pulse summer 53 is also provided.

Block 54 incorporates a fast analogue to digital converter 55 and a latch FIFO array 56. The analogue to digital converter 55 digitises the laser return signal received from the detector block 47. The digital samples are captured in FIFO 56. A counter 57 is used to provide a count of elapsed time between the firing of the laser and the return of target signal pulses, so that a range can be calculated. A high stability oscillator module 58 is provided as a pulse source for the counter 57. The block 54 also includes gain control module 59 for controlling the gain of amplifiers 50 and 51 in accordance with control signals from the TMS 320 C25 microprocessor 25.

In operation, under control of the digital signal processing core microprocessor 25, the fast analogue to digital converter 55 samples the analogue signal received by the detector block 47 at a 40 MHz clock rate and stores the samples in the FIFO array 56. The sampled waveform is then further processed by the DSP microprocessor 25, with regard to the time information

provided by the counter on the time between the firing of the laser 35 and the return of target signal returns. Signal processing algorithms use statistical signal analysis, signal interpolation techniques, slope analysis and amplitude analysis to identify valid target returns and accurately determine the first time of detection (see description in preamble of the specification). Linear interpolation in rising edge analysis is used to determine the actual time of arrival of any target signal return. The relative strengths of each target signal return are also determined by the DSP microprocessor 25. The entire digitised waveform is then stored in a battery backed internal static RAM memory in microprocessor 21. Time is quantised as a memory address to the SRAM for the stored digital waveform.

Note that, in a preferred embodiment, the last five processed complete signal return solutions are stored in the SRAM. This enables the operator to analyse the information from the last five laser firing episodes at his leisure, perhaps away from danger.

Using the information stored in the SRAM, microprocessor 21 can drive display 45 to provide information on a number of targets providing reflection pulses, the relative ranges of the targets and the relative strengths of the return signal, for any processed waveform stored in the SRAM, and in response to operator control 23. All of the ranging information is available for analysis, and several analyses can be performed, since all the ranging information has been recorded. In conventional rangefinders, only one analysis may be performed, and the analysis is only a GO/NO-GO test. With the laser rangefinder of this embodiment of the present invention, after one ranging operation the user may interact with the entire return signal information and find the range to any and/or all targets from which a reflection has been detected.

A description of operation of the device of figures 1 and 2 will now be given with reference to the

example battlefield target situation illustrated in figure 4. With reference to figure 4a, the operator of the rangefinding apparatus 1 is positioned at position A. The operators desired target is a tank 100 positioned at point B, some unknown distance from the operator at point A. In-line with the desired target 100 are undesired targets, tank 101 and background topography (hills) 102, positioned at C (closer to A than B) and D (further away from A than B), respectively. This typifies a crowded battlefield situation.

The operator sights the target 100 through the viewer optics 42 (cross hairs are provided to assist in target sighting) and presses the charge button 7 on the device 1. Referring to figure 5a, an example view of what would appear in the operators eyepiece is illustrated. The "C" indicator, indicates that the device is ready to be charged. After the charge button 7 has been pressed and when the discharge circuit 34 is fully charged, the "ready to fire" indicator, "F" appears in the eyepiece 4 display (see figure 5b). The operator then presses the fire button 10 and the laser module 35 produces a laser pulse which is transmitted by the transmitter optics 32 as laser pulse 103 (figure 4a). PIN diode 36 detects the firing of the laser pulse and initiates the counter 57 (figure 2).

Note that the laser module 35 includes a conventional Q-switch. As discussed above, the laser itself is an erbium-glass laser. Q-switching, involves closing off the output of the laser to let the gain inside the laser cavity build up, then suddenly switching the laser to allow an output for a short period of time before shutting off the output again. Q-switching is known in the art, and persons skilled in the art will be aware of several techniques to achieve Q-switching operation. The presently preferred embodiment of the invention utilises a rotating prism Q-switch.

As discussed above, the laser transmitter optics 32 consists of a Galilean telescope to collimate the

laser beam. The system has an expansion ratio of eight times. The coma aberration for this design is always inward and therefore the kematic tail from off-access rays tends to add to the centre of the beam and improve diversions.

It will be appreciated that other methods of producing and transmitting a laser pulse could be used with the present invention.

Referring again to figure 4a, it can be seen that targets C and D as well as desired target B, are in the path of the transmitted laser pulse 103. The device 1 will therefore receive target signal returns (laser pulse reflections) from C and D as well as B. Note that in many battlefield situations (or even in many commercial applications) it is quite likely that even more target return signals than this will be received, depending upon how cluttered the field of view is.

The reflected laser return signal is received by receiver optics 39, and transmitted via wavelength filter 41 to detector 48 (figure 2).

Figure 4b is a representation of the raw return signal from laser pulse 103. The abscissa represents the amplitude of the laser return signal and the ordinate is in the time domain. 101 C, 100B and 102D represent the target signal returns for each respective target 101, 100 and 102, respectively.

Note that in a conventional analogue rangefinding device, as discussed above, only a single signal will be processed. In some conventional devices, as discussed in the preamble, it is possible, by utilising a gating facility, or a first/last facility, to exercise some control over the selection of the target pulse to be ranged where there are a multiplicity of targets. Control is very limited, however. With a first/last function in the present case, for example, only target 100 or 102 would be ranged. The desired target would not be ranged. With a conventional rangefinder, the operator would have no confidence in his

rangefinding results, in a multiple target situation (which could quite possibly be in the majority of cases). In the present case, following digital processing of the signal, information is given on all of the targets from which a target signal return is received. This allows the operator to make a range-finding decision with confidence.

Note that with the detector 47 of the present invention, the variable gain amplifier 51 can be operated by gain control 59 in two modes, normal gain for duration of capture of the return signal or attenuated gain for the first two kilometres of capture followed by normal gain. When operating with normal gain, returns in the near field (less than 2 kilometres, for example) can cause saturation of the receiver amplifier circuitry. This saturation can last greater than 1000 metres, thus obscuring any other valid targets in this region. This saturation can occur due to the following conditions:

1. Rain
2. Smoke in near field.
3. Shooting from above/behind/through trees (any non clear shot).

By selecting the "de-clutter" mode using selection buttons 9 (figure 1), for less than two kilometre attenuation of return signal, the amplifiers are less likely to be driven into saturation, thus preserving the multiple target information that may exist.

The "de-clutter" mode is not used for all cases. For example, small targets approaching two kilometres may not be picked up with attenuated gain, and amplifier circuitry causes a DC shift in waveform as a hump when the gain changes to normal/full gain. This can make it difficult to pick targets around the hunt region.

The operator is therefore able to select whether to use this facility or not.

Referring again to figures 4 and 2, the return signal detected by detector 47 is amplified as previously

discussed and then digitised by block 54, digital samples being stored in FIFO 56. As also discussed previously, digital signal processing is applied under the control of microprocessor 25 to create a digital representation of the return signal, which is stored in SRAM of microprocessor 21, with time being quantised as a memory address of the SRAM. Note that a number of digital signal processing techniques may be applied to provide accurate analysis of the return signal and give accurate figures on target signal strength and range of targets. As discussed above, rising edge analysis is performed to obtain an accurate range for each target signal return. Experience based software algorithms may also be applied to assist in obtaining accurate ranging information. The relative strength of the target signal return may be obtained from integrating the signal pulse (the shape of the actual pulse will tend to be corrupted on its way back from the target, by obstacles present in the air, e.g., aerosols).

Ranging decisions and strength of signal decisions can be based on a number of digital analysis techniques, e.g. noise characterisation, multi-shot averaging and multiple target ranging. The analysis techniques are very flexible as they are not restricted by rangefinder hardware, but only be available digital signal processing hardware and time. A person skilled in the art will appreciate that many different digital analysis techniques may be applied.

Following digital signal processing, microprocessor 21 is arranged to control the generation of a display on CRT 45, based on the information stored in the internal SRAM. The display is in the form of histogram representations of the target return signals 101C, 100B, 102D. See, in particular, figure 4c, which is a representation of the type of display which would be generated from the raw return signal of figure 4b. The relative separation of each bar in the histogram display gives the operator an idea of the relative distance of

each respective target. Note that the base line 105 of the display is in the distance domain. The relative height of each bar shows the relative strength of the associated target signal. The device is arranged to automatically generate a display of the actual range to the target which generated the largest target return signal (see figure 5c - the range to the largest target signal is indicated at the bottom of the eyepiece 4 as being 10128 metres. The top of the eyepiece 4 shows the histogram display with an indicator 106 which indicates which target the range is displayed for).

The operator is therefore presented with information on the relative strengths of the return signals for each target, and the relative ranges to each target. Utilising this information, together with his line of sight display of the battlefield (or, if he wishes to view the display somewhere else, his memory of the battlefield situation) the operator is able to easily determine which target is the desired target. In the situation of figure 4a, using his judgement of distance he will appreciate that the background hills may well be providing the largest return and that his desired target cannot be in the order of 10 kilometres away. He will also appreciate that the closest tank 101 is probably going to provide a return signal, being the nearest return signal shown on the histogrammatic display. He will therefore determine that target 100 is the centre bar on the histogrammatic display. To obtain a readout of actual range to the centre button, the operator depresses selection buttons 9 which cause selector 106 to move in a downward direction (in accordance with arrows on selection buttons 9) to the centre bar (see figure 5d). The actual range to the centre bar is then displayed at the foot of the eyepiece display 4, as 7323 metres.

In a preferred embodiment, the display also provides an indication as to whether the targets are "clustered" or not. Clustered targets are defined as a

number of targets (two or more) within a predetermined distance of each other. For example, a group of vehicles in convoy or a group of trucks surrounding a tank or gun emplacement may provide multiple returns within a "cluster". In the present embodiment, any target signal returns less than 1000 metres apart are considered to be clustered targets (note that any returns less then 30 metres apart are shown as a single target). Clustered targets are shown on the histogrammatic display as a single bar, the bar being wider than for the bars for returns from single targets. This clearly indicates to the operator that the wide bar is for clustered targets and he may process the ranges to individual targets within the cluster. This information further assists in identifying the desired target.

The above-described embodiment of the present invention, therefore provides the operator with information on all target signal returns (with the exception, in the preferred embodiment, of targets within 30 metres of each other - in that case only the first target return signal is required), their relative ranges and relative strengths, in an easy to read display. Prior art laser rangefinding devices are unable to do this.

Note that the present invention may be applied in rangefinding devices which use other types of transmission and reception apparatus. The present invention relates specifically to the way in which the received information is processed and the information which is presented to the operator.

It will be appreciated by persons skilled in the art that numerous variations and/or modifications may be made to the invention as shown in the specific embodiments without departing from the spirit or scope of the invention as broadly described. The present embodiments are, therefore, to be considered in all respects as illustrative and not restrictive.

CLAIMS:

1. A rangefinding device, comprising apparatus for processing an analogue return signal to recover range information on multiple targets, digital analysis means arranged to digitally analyse the return signal to identify target signals, being signal returns which satisfy predetermined criteria, range determination means arranged to make a determination of the range of each target identified, and a display controller arranged to control a display to simultaneously display information on at least a plurality of the identified target signals to give an indication of the relative positions of the plurality of targets corresponding to the plurality of target signals.

2. A device in accordance with claim 1, further comprising strength determination means arranged to make a determination of the strength of each of the plurality of target signals, and wherein the display controller is arranged to control the display to display information indicating the relative strength of at least the plurality of target signals.

3. A device in accordance with claim 1 or claim 2, wherein the digital analysis means is arranged to analyse the return signal to identify all target signals included therein, the predetermined criteria including signal strength.

4. A device in accordance with claim 3, wherein the digital analysis means is arranged to analyse the return signal to determine which signals are statistically distinguishable from "noise".

5. A device in accordance with any one of claims 1 to 4, wherein the range determination means is arranged to make a determination as to whether a plurality of targets are within a predetermined distance of each other, and, if so, to determine that the plurality of targets are clustered targets, and the display controller is responsive to this determination to cause the display to indicate that the plurality of targets are clustered.

6. A device in accordance with any one of the preceding claims, control means being provided for selecting any of the targets on which information is displayed, the display controller being responsive to said selection to cause the display to display the actual range of the selected target.

7. A device in accordance with any one of the preceding claims, wherein the range determination means employs linear interpolation of the rising edge of a target signal in order to determine the distance to the target.

8. A device in accordance with any one of the preceding claims, further comprising an amplifier for amplifying the return signal and a variable gain control means for controlling the gain of the amplifier so that the gain may be lower in the near field than in the far field.

9. A device in accordance with any one of claims 2 to 8, wherein the display controller is arranged to cause the display to produce a histogrammatic display, wherein each of the plurality of target signals is represented as a histogram bar, the distance between histogram bars on the display being indicative of the relative distance between the targets represented by histogram bars, and the size of the histogram bar being indicative of the relative strength of the return signals.

10. A device in accordance with claim 5, a plurality of signals determined to represent clustered targets being represented as a single bar on the display, of greater width than the bars representative of single targets.

11. A device in accordance with any preceding claim, wherein the display controller is arranged to control the display to automatically display the range of the target giving the largest signal return.

12. A rangefinding device, comprising apparatus for processing an analogue return signal to recover information on multiple targets, comprising digital

analysis means arranged to digitally analyse the return signal to identify target signals, being signal returns which satisfy predetermined criteria, and arranged to make a determination of the strength of a plurality of target signals, and a display controller arranged to control a display to display information on the relative strength of the plurality of target signals.

13. A device in accordance with claim 12, further comprising range determination means arranged to make a determination of the range of each target identified, and to cause the display controller to control the display to give an indication of the relative positions of the plurality of targets corresponding to the plurality of target signals.

14. A device in accordance with claim 12 or claim 13, wherein the digital analysis means is arranged to analyse the return signal to identify all target signals included therein, the predetermined criteria being signal strength.

15. A device in accordance with claim 14, wherein the digital analysis means is arranged to analyse the return signal to determine which signals are statistically distinguishable from "noise".

16. A device in accordance with any one of claims 12 to 15, control means being provided for selecting any of the targets on which information is displayed, the display controller being responsive to said selection to cause the display to display the actual range of the selected target.

17. A device in accordance with any one of claims 12 to 16, further comprising an amplifier for amplifying the return signal and variable gain control means for controlling the gain of the amplifier so that the gain is lower in the near field than in the far field.

18. A device in accordance with any one of claims 12 to 17, wherein the display controller is arranged to cause the display to produce a histogrammatic display, wherein each of the plurality of target signals is

represented as a histogram bar, the size of the histogram bar being indicative of the relative strength of the particular return signal.

19. A rangefinding device, comprising an apparatus for processing an analogue return signal to recover range information on multiple targets, comprising digital analysis means arranged to digitally analyse the return signal to identify all targets from which a reflection has been received and are included in the return signal, being signal returns which satisfy predetermined criteria.

20. A device in accordance with claim 19, further comprising a display controller arranged to control a display to display information on all the targets identified, being information on the relative range for all the targets identified and/or relative signal strength of the return signal for all the targets identified.

21. In a rangefinding device, a method of processing an analogue return signal to recover range information on multiple targets, comprising the steps of digitally analysing the analogue return signal to identify target signals, being signal returns which satisfy predetermined criteria, determining the range of each target identified, and controlling a display to simultaneously display information on at least a plurality of the identified target signals to give an indication of the relative positions of the plurality of targets corresponding to the plurality of target signals.

22. A method in accordance with claim 21, further comprising the step of determining the strength of each of the plurality of signals and the step of controlling the display to display information indicating the relative strength of at least the plurality of target signals.

23. A method in accordance with claim 21 or 22, wherein the step of identifying target signals comprises identifying all the target signals included in the return signal, and wherein the predetermined criteria is signal strength.

24. A method in accordance with claims 21, 22, or 23, comprising the further steps of determining whether a plurality of targets are within a predetermined distance of each other and, if they are, controlling the display to indicate that this plurality of targets are clustered targets.

25. A method in accordance with any one of claims 21 to 24, comprising the further step of, in response to actuation of control means to select a displayed representation of a target signal, displaying the actual range of the target represented by the displayed representation.

26. A method in accordance with any one of claims 22 to 25, wherein, in the step of controlling the display, the display is controlled to produced a histogrammatic display, wherein each of the plurality of target signals is represented as a histogram bar, the distance between the histogram bars on the display being indicative of the relative distance between the targets represented by the histogram bars, and size of the histogram bars being indicative of the relative strength of the return signals for each target signal.

27. In a rangefinding device, a method of processing an analogue return signal to recover information on multiple targets, comprising the steps of digitally analysing the analogue return signal to identify target signals, being signal returns which satisfy predetermined criteria, determining the strength of each of a plurality of the target signals and controlling a display to display information indicating the relative strength of at least the plurality of target signals.

28. In a rangefinding device, a method of processing an analogue return signal to recover information on multiple targets, comprising the steps digitally analysing the analogue return signal to identify all target signals included in the digital representation, being signal returns which satisfy predetermined criteria, predetermined criteria being the strength of the signal

return, a signal return being identified as a target signal if it is over a predetermined strength value.

29. A device in accordance with any one of claims 1 to 20, comprising memory means for storing the digital analysis results of an analysis of a plurality of return signals, for subsequent analysis.

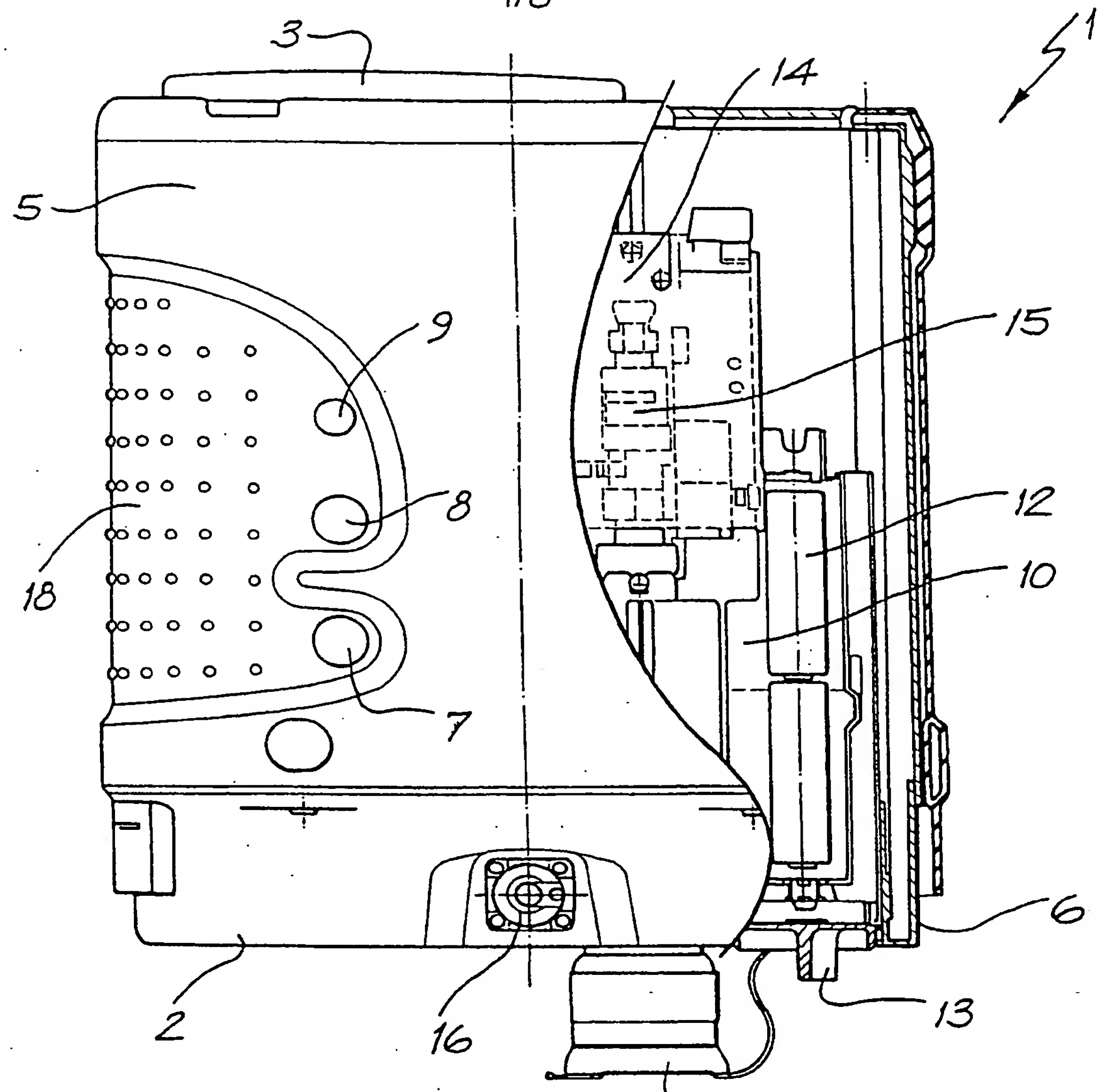


FIG. 1

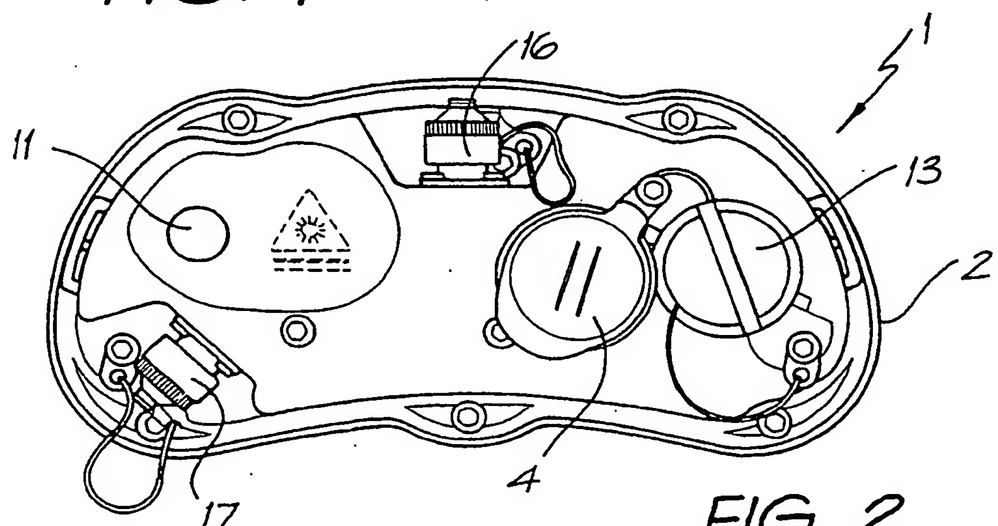


FIG. 2

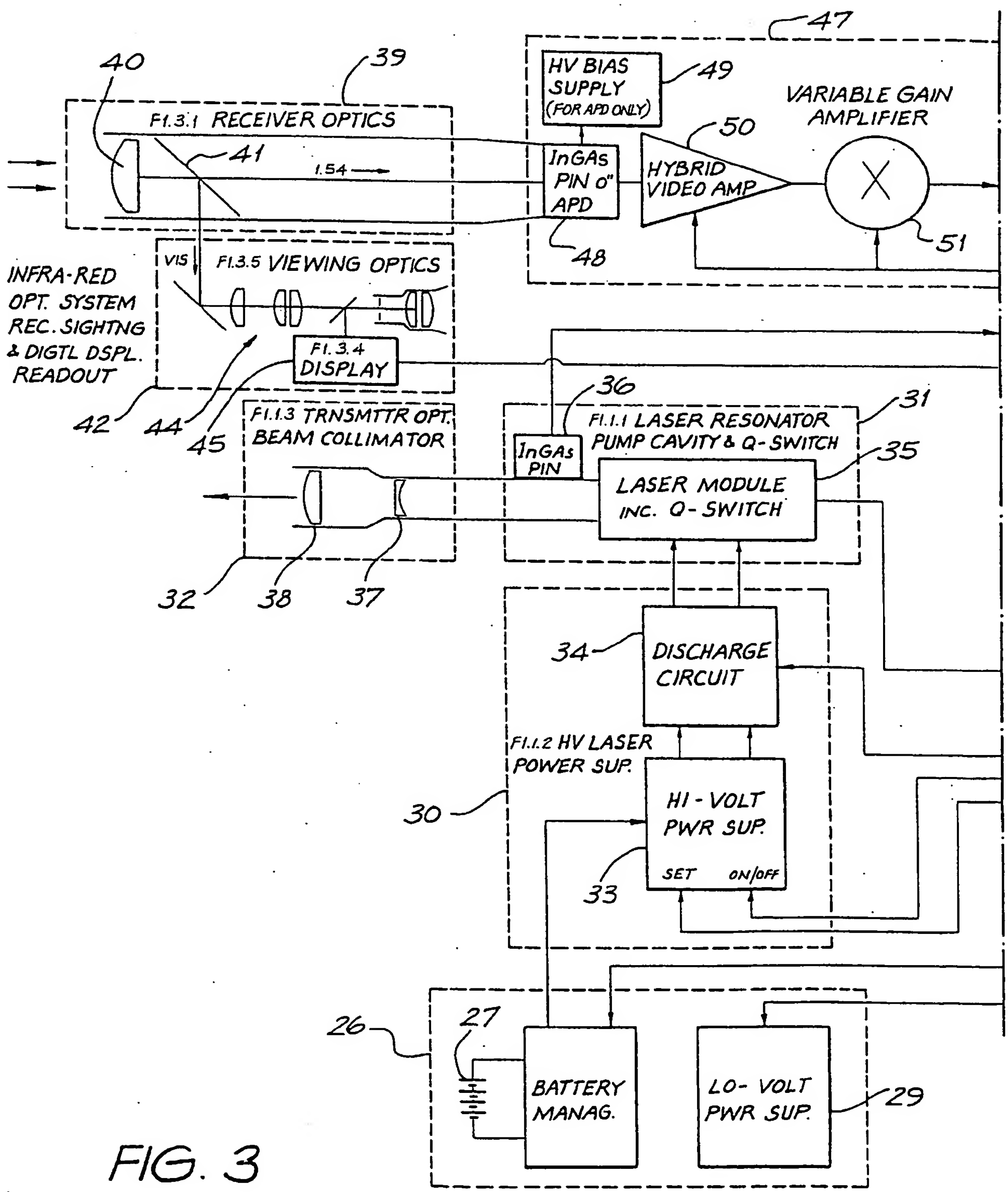

47
HV BIAS SUPPLY (FOR APD ONLY)
49
VARIABLE GAIN AMPLIFIER
40
39
F1.3.1 RECEIVER OPTICS
41
1.54
InGAs PIN o" APD
50
HYBRID VIDEO AMP
51
48
VIS
F1.3.5 VIEWING OPTICS
INFRA-RED OPT. SYSTEM REC. SIGHTNG & DIGTL DSPL. READOUT
F1.3.4 DISPLAY
36
31
F1.1.1 LASER RESONATOR PUMP CAVITY & Q-SWITCH
42
44
45
F1.1.3 TRNSMTTR OPT. BEAM COLLIMATOR
InGAs PIN
35
LASER MODULE INC. Q-SWITCH
32
38
37
34
DISCHARGE CIRCUIT
F1.1.2 HV LASER POWER SUP.
30
HI-VOLT PWR SUP.
SET
ON/OFF
33
26
27
BATTERY MANAG.
LO-VOLT PWR SUP.
29

FIG. 3

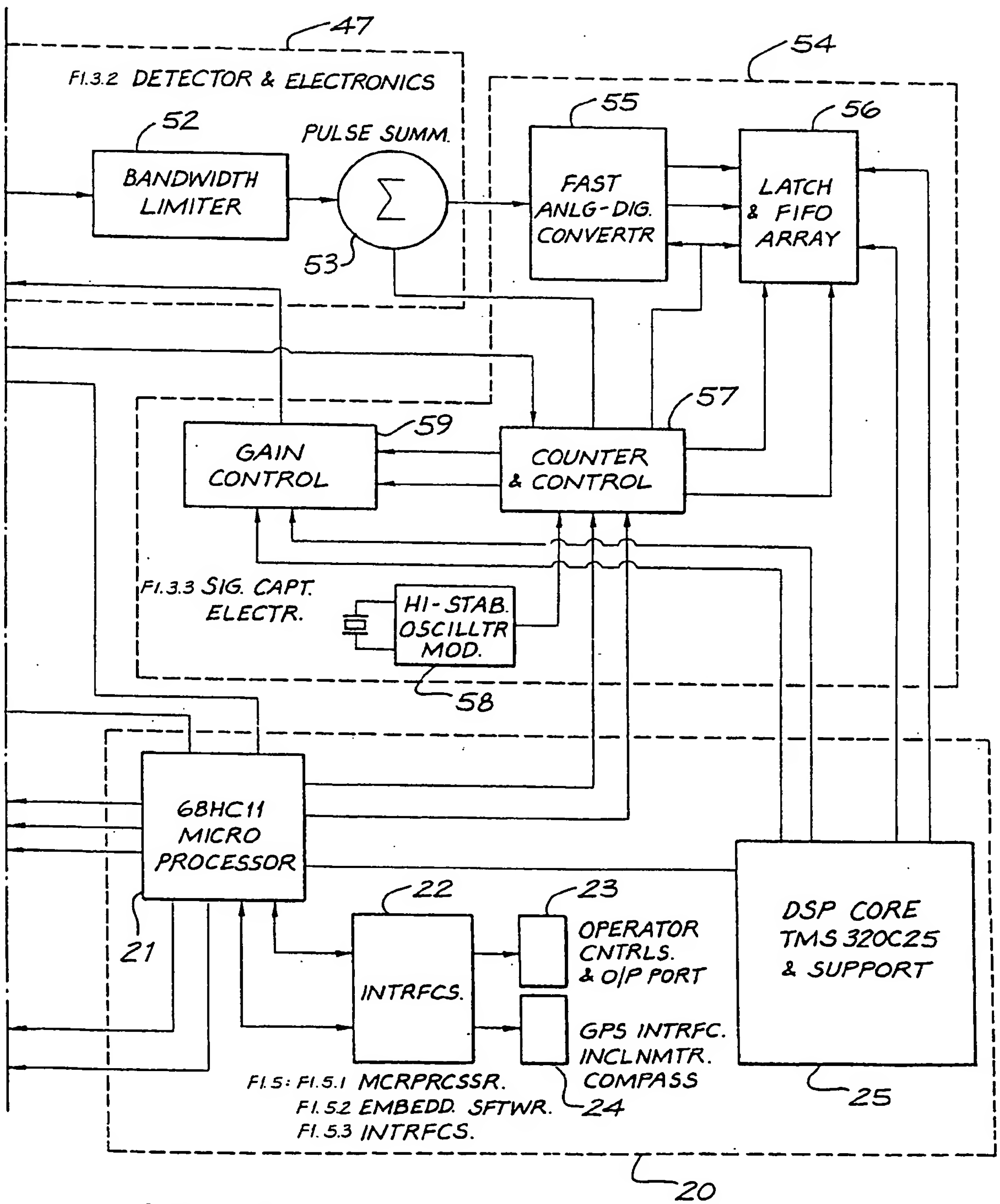


FIG. 3-CONTINUED

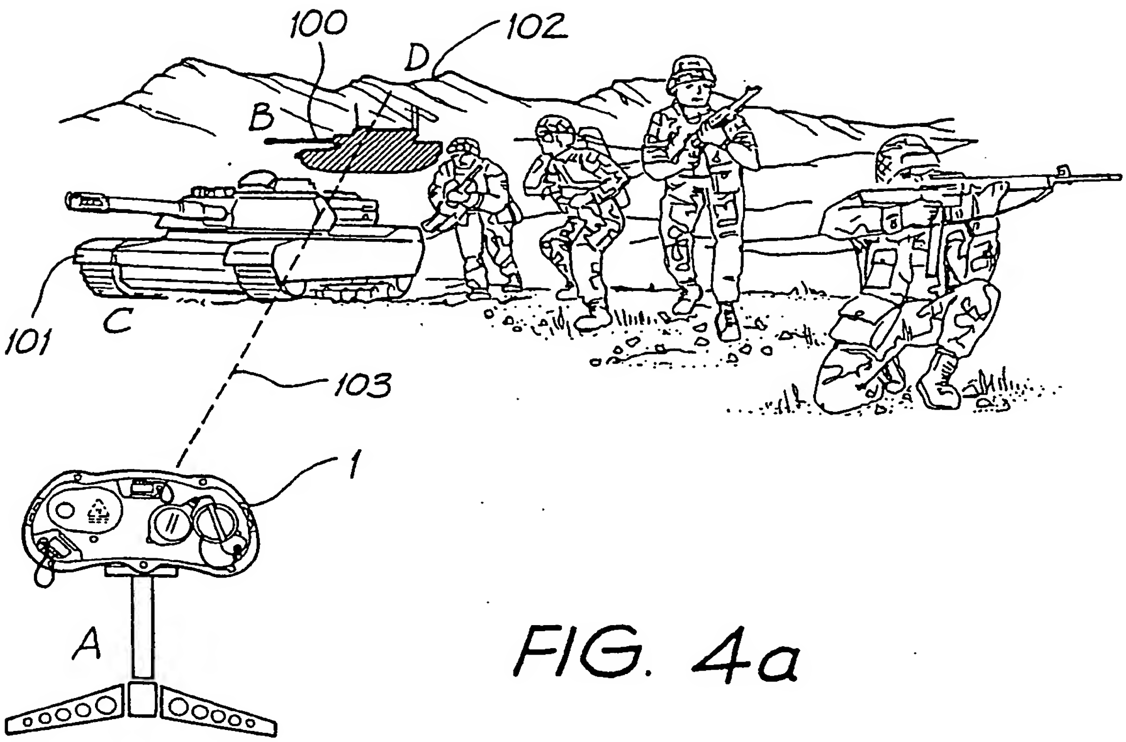


FIG. 4a

RAW RETURNED SIGNAL

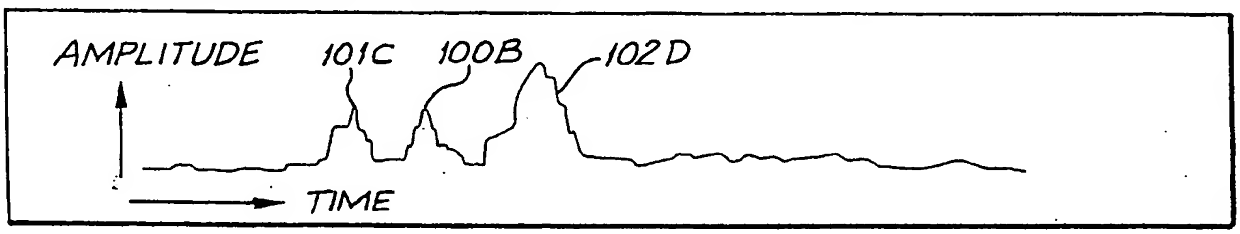


FIG. 4b

DIGITIZED AND PROCESSED SIGNAL FROM ESLR-1000

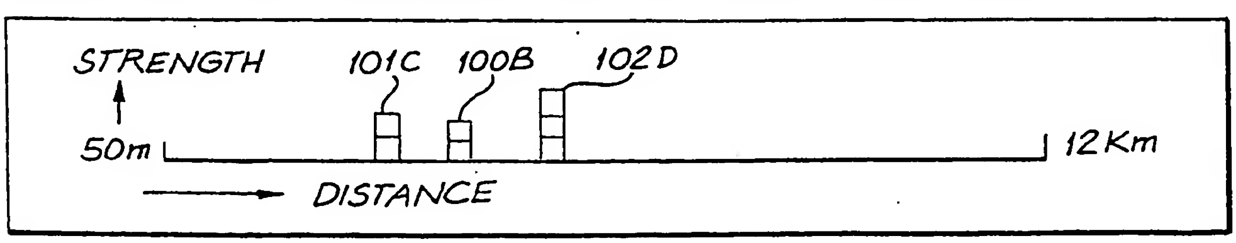
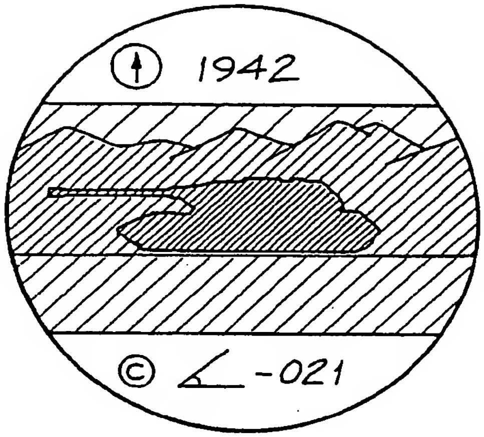


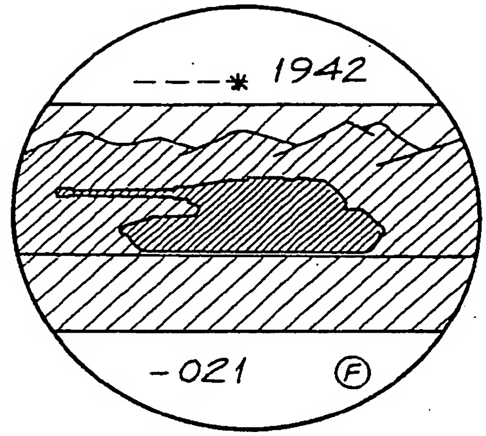
FIG. 4c

SUBSTITUTE SHEET (RULE 26)



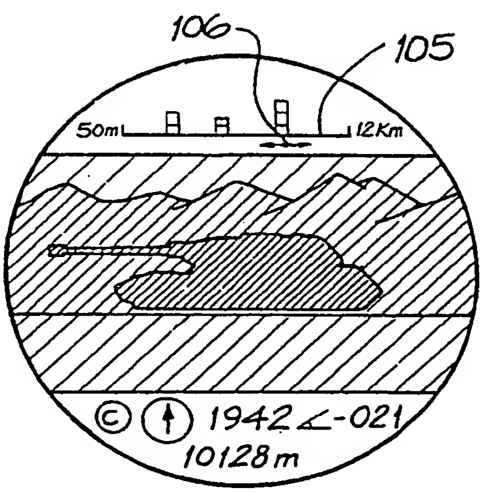
STEP 1.
READY TO BE CHARGED

FIG. 5a



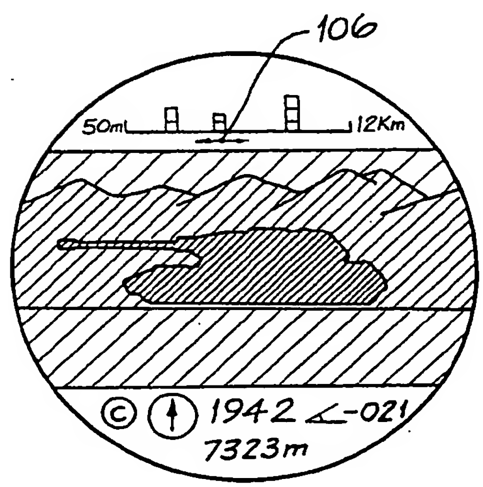
STEP 2.
READY TO FIRE (RANGE)

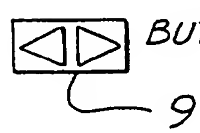
FIG. 5b



BY DEFAULT, RANGE OF THE LARGEST TARGET IS DISPLAYED & INDEXED BY INDICATOR ON RANGE TARGET BAR.

FIG. 5c





BUTTONS PRESSED

FIG. 5d

INTERNATIONAL SEARCH REPORT

International Application No.
PCT/AU 96/00338

A. CLASSIFICATION OF SUBJECT MATTER

Int Cl^{6}: G01C 3/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC : G01C 3/-

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
DERWENT and JAPIO. Keyword "rangefinder:"

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5371581 A (WANGLER ET AL) 6 December 1994 Abstract	1, 19, 20, 21, 29
X	GB 2276997 A (KOLLMORGEN CORPORATION) 12 October 1994 Abstract	1, 19, 20, 21, 29
A	US 4699507 A (NISSAN MOTOR COMPANY LTD) 13 October 1987	

[X] Further documents are listed in the continuation of Box C

[X] See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
12 August 1996	4 SEP 1996

Name and mailing address of the ISA/AU	Authorized officer
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INTERNATIONAL SEARCH REPORT

...ernational Application No.
PCT/AU 96/00338

C (Continuation)	DOCUMENTS CONSIDERED TO BE RELEVANT	
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	GB 2125649 A (EASTMAN KODAK COMPANY) 7 March 1984	
A	EP 465375 (FUJI KURA LTD) 8 January 1992	
A	EP 373979 (THOMSON CSF) 20 June 1990	

INTERNATIONAL SEARCH REPORT
Information on patent family members

International Application No.
PCT/AU 96/00338

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
GB	2276997	CA	2120799	EP	619502	JP	7019861
US	4699507	JP	60201276				
GB	2125649	HK	523/86	JP	59058307	US	4490037
EP	465375	JP	4067276	US	5212547	JP	4089517
EP	373979	DE	68906253	FR	2639108	US	5195144

END OF ANNEX